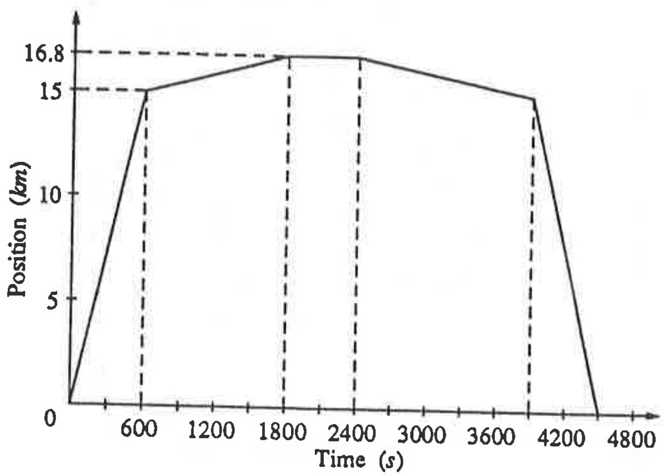
Distance walked to station
= (1.5 m/s)(20.0 min)(60 s/min)
= 1800 m.

Time for walk back to car
$= \frac{(1800 \text{ m})}{(1.2 \text{ m/s})}$
= 1500 s.

b. Draw a position–time graph for the problem from the areas under the curves of the velocity–time graph.



From the graph in part a, the changes in position are:

$\Delta d_1 = A_1$ = (25 m/s)(600 s)
= 15 000 m = 15 km

$\Delta d_2 = A_2$ = (1.5 m/s)(1200 s)
= 1800 m = 1.8 km

$\Delta d_3 = A_3$ = (−1.2 m/s)(1500 s)
= −1800 m = −1.8 km

$\Delta d_4 = A_4$ = (−25 m/s)(600 s)
= −15 000 m = −15 km

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20. From the reference frame of a stationary observer, a car, traveling at a constant speed of 92 km/h, is passed by a truck moving at 105 km/h.

a. From the point of view of the car, what is the truck's speed?

If $V_B = V_A + V_{BA}$, where V_A, V_B are velocities relative to Earth and V_{BA} is the velocity of *B* relative to *A*, then
$V_{BA} = V_B - V_A$.

$V_{tc} = V_t - V_c$ = 105 km/h − 92 km/h
= 13 km/h

b. From the point of view of the truck, what is the car's speed?

$V_{ct} = V_c - V_t$ = 92 km/h − 105 km/h
= −13 km

21. As you travel at a constant 95 km/h, a car that you know to be 3.5 m long, passes you in 1.8 s. How fast is it going relative to Earth?

The relative speed is $\frac{(3.5 \text{ m})}{(1.8 \text{ s})}$ = 1.9 m/s = 7.0 km/h, so its speed is 102 km/h.

Chapter Review Problems

pages 59–61

1. While John is traveling along an interstate highway he noticed a mile marker read 160 as he passed through town. Later John passed another mile marker, 115.

a. What is the distance between town and John's current location?

45 miles

b. What is John's current position?

+115

2. While John is traveling along a straight interstate highway he noticed that the mile marker reads 260. John traveled until he reached the 150 mile marker and then retraced his path to the 175 mile marker. What is the magnitude of John's resultant displacement from the 260 mile marker?

$\Delta d = d_2 - d_1$ = 175 mi − 260 mi = −85 ~~mi~~ km

3. A physics book is moved once around the perimeter of a table of dimensions 1.0 m by 2.0 m.

   a. If the book ends up at its initial position, what is its displacement?

   Any time a book ends up where it started its displacement is zero.

   b. What is the distance traveled?

   The distance is equal to the perimeter of the table, 6.0 m.

4. Light from the sun reaches Earth in 8.3 min. The velocity of light is 3.00×10^8 m/s. How far is Earth from the sun?

   Time = 8.3 min = 498 = 5.0×10^2 s

   $$\bar{v} = \frac{\Delta d}{\Delta t},$$

   so $\Delta d = \bar{v}\Delta t = (3.00 \times 10^8 \text{ m/s})(5.0 \times 10^2 \text{ s})$
   $= 1.5 \times 10^{11}$ m

5. You and a friend each drive 50 km. You travel at 90 km/h, your friend at 95 km/h. How long will your friend wait for you at the end of the trip?

   It takes your friend $\frac{(50 \text{ km})}{(95 \text{ km/h})} = 31.6$ minutes,

   and takes you $\frac{(50 \text{ km})}{(90 \text{ km/h})} = 33.3$ minutes, so your friend waits 1.8 minutes.

6. From the list of winning times from the 1988 Summer Olympics, in Table 3–2, calculate the average speeds for each race. Assume the length of each event is known to the nearest 0.1 m.

Chapter Review Problems

Length of event (m)	Time (min:sec) Men	Women
100	9.92	10.54
200	19.75	21.34
400	43.87	48.65
800	1:44.06	1:56.10
1 500	3:35.96	3:53.96
3 000		8:26.53
5 000	13:11.70	
10 000	27:21.46	31:05.21

Length of event (m)	Velocity (m/s) Men	Women
10.1	10.1	9.488
200	10.13	9.372
400	9.118	8.222
800	7.688	6.891
1 500	6.9457	6.411
3 000		5.9227
5 000	6.3155	
10 000	6.09214	5.36133

7. Construct a table similar to Table 3–2 listing average speeds for track events in your school, district, or state.

   Students answers will vary.

8. Construct an average speed table similar to Problem 6 for swimming events at your school, district, or state. Compare times for swimming to those for running. Explain.

Student answers will vary.
Students can run faster than they can swim.

9. Two cars approach each other; both cars are moving westward, one at 78 km/h, the other at 64 km/h.

a. What is the velocity of the first relative to (in the frame of reference of) the second?

Let east be the positive direction.

Initially car 1 is going –78 km/h and car 2 is going –64 km/h. To use car 2 as our reference point add the opposite of its current velocity, +64 km/h, to give it a zero speed. Add +64 km/h to car 1's velocity also; –78 km/h + (+64 km/h) = –14 km/h or 14 km/h, west.

b. After they pass, will their relative velocity change?

No

10. Ann is driving down a street in a car at 55 km/h. Suddenly a child runs into the street. If it takes Ann 0.75 s to react and apply the brakes, how many meters will she have moved before she begins to slow down?

$$\bar{v} = \frac{\Delta d}{\Delta t}, \text{ so}$$

$$\Delta d = \bar{v}\Delta t = \frac{(55 \text{ km/h})(0.75 \text{ s})(1000 \text{ m/km})}{(3600 \text{ s/h})}$$

$$= 11 \text{ m}$$

11. You plan a trip on which you want to average 90 km/h. You cover the first half of the distance at an average speed of only 48 km/h.

a. What must your average speed be in the second half of the trip to meet your goal? Note that velocities are based on half the distance, not half the time.

$$\bar{v} = \frac{\Delta d}{\Delta t}, \text{ so } \Delta t = \frac{\Delta d}{\bar{v}}$$

Let $d = \frac{1}{2}d + \frac{1}{2}d$ and $t_{total} = t_1 + t_2$,

$$\text{so } \frac{d}{v} = \frac{\frac{1}{2}d}{v_1} + \frac{\frac{1}{2}d}{v_2} \text{ multiply by } 2d$$

$$\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2},$$

$$\text{so } \frac{1}{v_2} = \frac{2}{v} - \frac{1}{v_1}$$

$$= \frac{2}{90 \text{ km/h}} - \frac{1}{48 \text{ km/h}}$$

so $v_2 = 720$ km/h

b. Is this a reasonable speed?

No

12. You drive a car 2.0 hours at 40 km/h, then 2.0 hours at 60 km/h.

a. What is your average velocity?

Total distance: 80 km + 120 km = 200 km. Total time 4.0 hours, so,

$$v = \frac{\Delta d}{\Delta t} = \frac{200 \text{ km}}{4.0 \text{ h}} = 50 \text{ km/h}.$$

b. Do you get the same answer if you drive 100 km at each of the two speeds above?

No. Total distance 200 km;

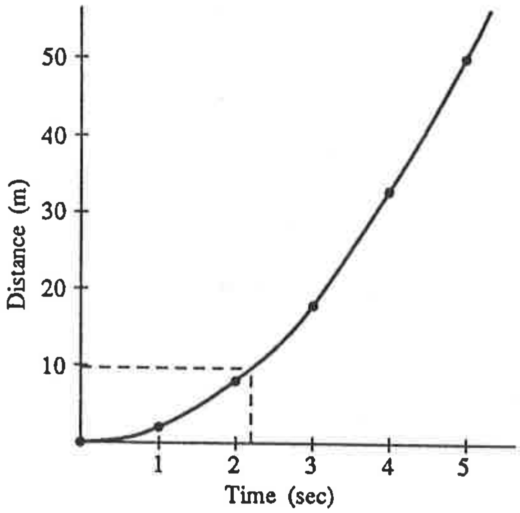
$$\text{total time} = \frac{(100 \text{ km})}{(40 \text{ km/h})} + \frac{(100 \text{ km})}{(60 \text{ km/h})}$$

= 2.5 h + 1.7 h = 4.2 h.

$$\text{So } v = \frac{\Delta d}{\Delta v} = \frac{200 \text{ km}}{4.2 \text{ h}} = 48 \text{ km/h}.$$

13. The total distance a steel ball rolls down an incline at the end of each second of travel is given in Table 3–3.

a. Draw a position–time graph of the motion of the ball. When setting up the axes use five divisions for each 10 m of travel on the d–axis. Use five divisions for each second of time on the t–axis.



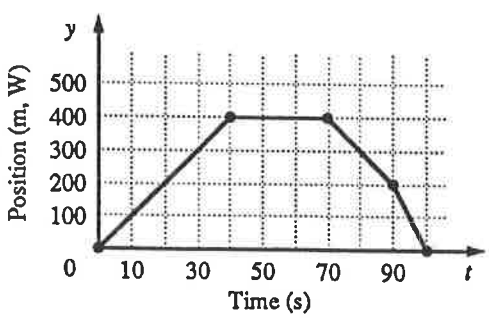
b. What type of curve is the line of the graph?

The curve is a parabola.

c. What distance has the ball rolled at the end of 2.2 s?

After 2.2 seconds the ball has rolled approximately 10 m.

14. Use the position–time graph in Figure 3–24 to find



Chapter Review Problems

a. How far the object travels between $t =$ and $t = 40$ s.

$$\Delta d = d_{40} - d_0 = 400 \text{ m} - 0 \text{ m} = 400 \text{ m}$$

b. How far it travels between $t = 40$ s and $t = 70$ s.

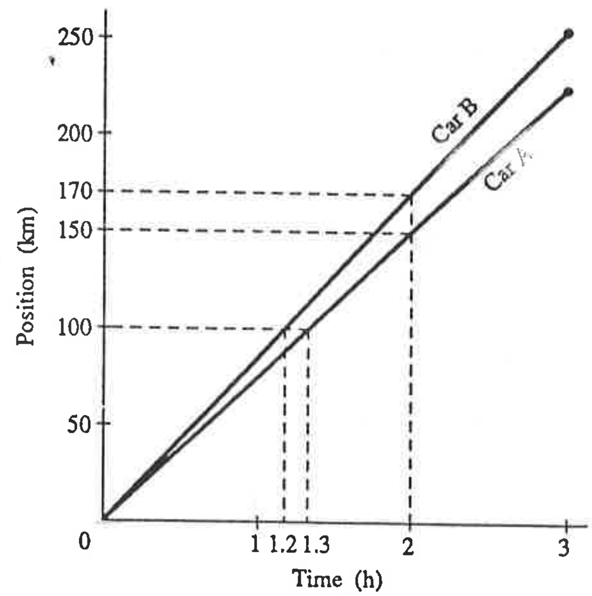
$$\Delta d = d_{70} - d_{40} = 400 \text{ m} - 400 \text{ m} = 0$$

c. How far it travels between $t = 90$ s and $t = 100$ s.

$$\Delta d = d_{100} - d_{90} = 0 - 200 \text{ m} = -200 \text{ m}$$

15. Both car A and car B leave school when a clock reads zero. Car A travels at a constant 75 km/h, while car B keeps its velocity 85 km/h.

a. Draw a position–time graph showing the motion of both cars.



b. How far are the two cars from school when the clock reads 2.0 hours? Calculate the distances using the equation of motion and show them on your graph.

$$d_A = v_A t = (75 \text{ km/h})(2.0 \text{ h}) = 150 \text{ km}$$

$$d_B = v_B t = (85 \text{ km/h})(2.0 \text{ h}) = 170 \text{ km}$$

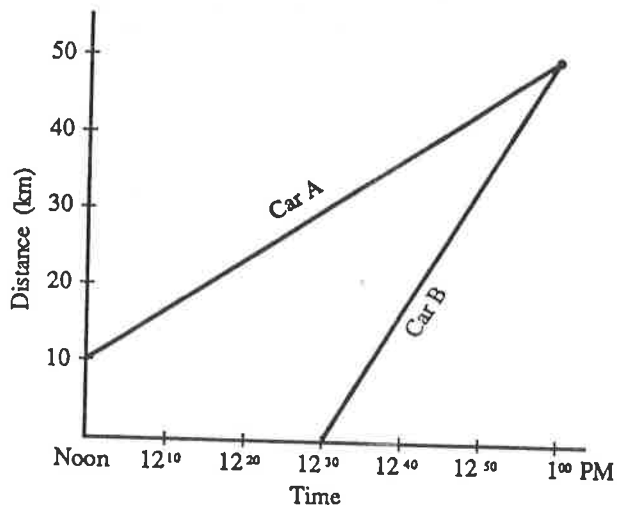
c. Both cars passed a gas station 100 km from the school. When did each car pass the station? Calculate the times and show them on your graph.

$$d = vt, \text{ so } t = \frac{d}{v}$$

$$t_A = \frac{d}{v_A} = \frac{100 \text{ km}}{75 \text{ km/h}} = 1.3 \text{ h}$$

$$t_B = \frac{d}{v_B} = \frac{100 \text{ km}}{85 \text{ km/h}} = 1.2 \text{ h}$$

16. Draw a position–time graph for two cars driving to the beach, 50 km from school. Car A leaves a store 10 km from school closer to the beach at noon, and drives at 40 km/h. Car B starts from school at 12:30 pm and drives at 100 km/h. At what time does each get to the beach?

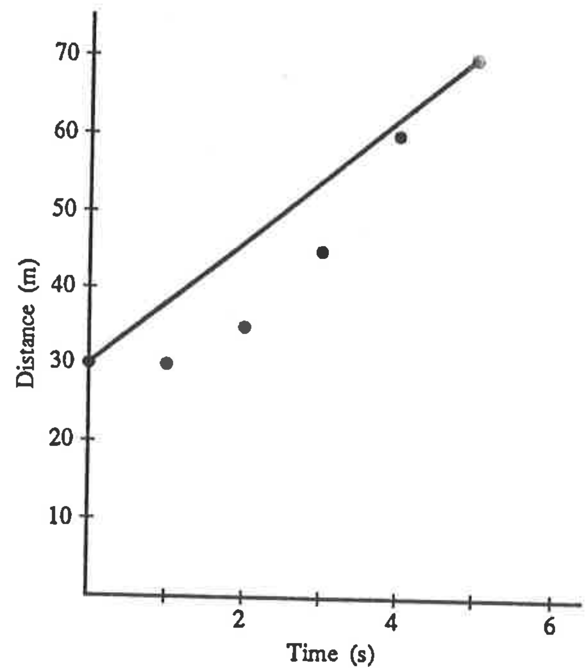


Both cars arrive at the beach at 1:00.

17. Plot the data in Table 3–1 on a position–time graph. Find the average velocity in the time interval between 0.0 and 5.0 seconds.

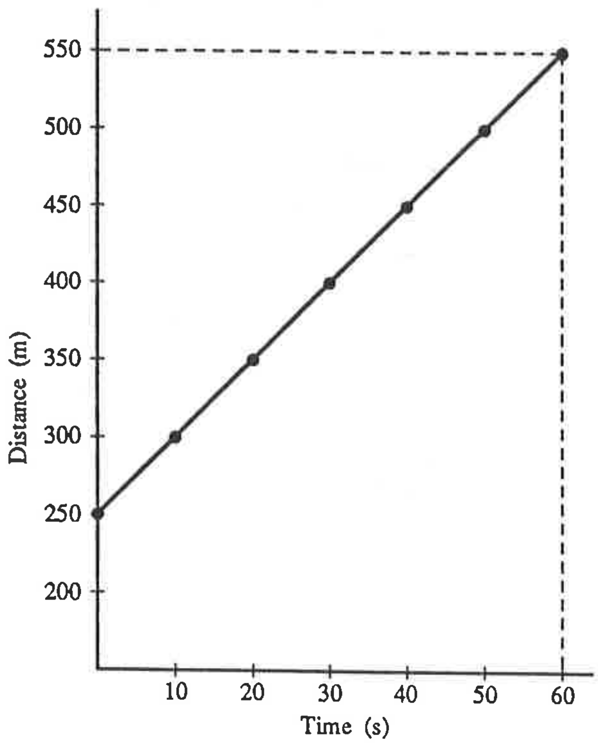
Table 3–1	
Clock Readings, t in s	Positions, d, in m
0.0	30
1.0	30
2.0	35
3.0	45
4.0	60
5.0	70

$$\text{slope} = \frac{\Delta d}{\Delta t} = \frac{70 \text{ m} - 30 \text{ m}}{5.0 \text{ s} - 0.0 \text{ s}} = 8.0 \text{ m/s}$$



18. A cyclist maintains a constant velocity of +5.0 m/s. At time t = 0, the cyclist is +250 m from point *A*.

a. Plot a position–time graph of the cyclist's location from point *A* at 10.0 second intervals for 60.0 s.



b. What is the position from point *A* at 60.0 s?

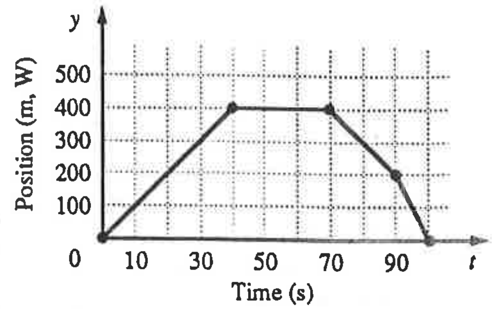
550 m

c. What is the displacement from the starting position at 60.0 s?

550 m − 250 m = 300 m

Chapter Review Problems

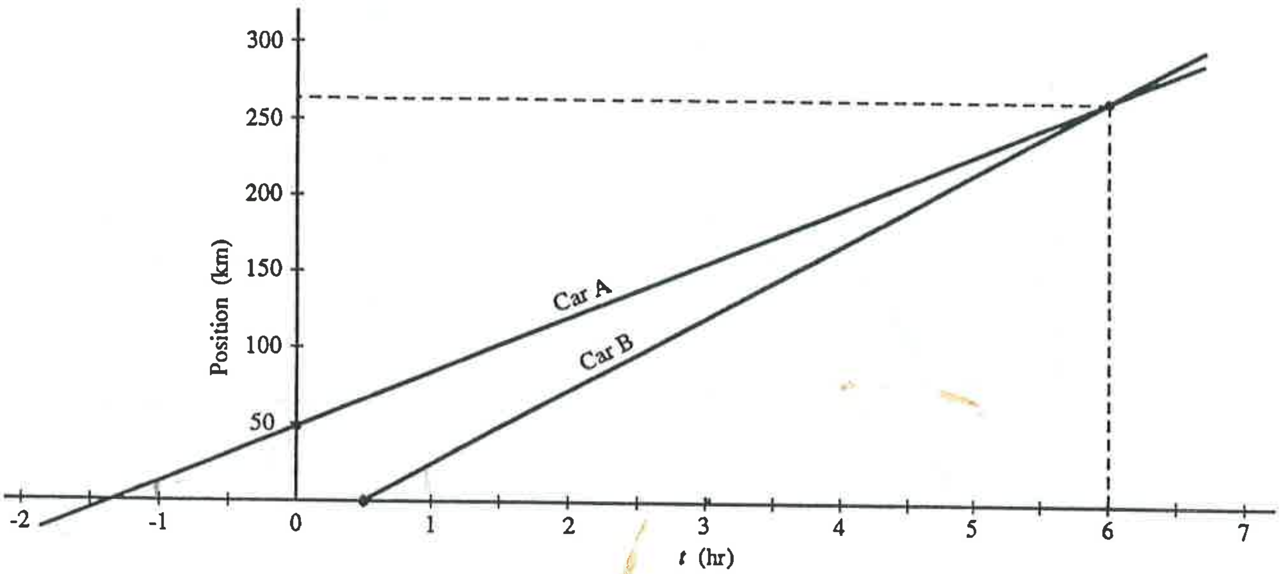
19. From the position–time graph, Figure ‑ construct a table showing the average velocity of the object during each 10–s interval over the entire 100 s.



Time interval (s)	Average Velocity (m/s)
0–10	10
10–20	10
20–30	10
30–40	10
40–50	0
50–60	0
60–70	0
70–80	−10
80–90	−10
90–100	−20

20. Two cars travel along the same straight road. When a stopwatch reads t = 0.0 hr car A is at d_A = 48.0 km moving at a constant 36.0 km/h. Later, when the watch reads t = 0.50 hr car B is at d_B = 0.00 km moving at 48.0 km/h. Solve the following questions first graphically by creating a postion–time graph, second algebraically by writing down equations for the positions d_A and d_B as a function of the stopwatch time t.

a. What will the watch read when car B passes car A?



6.00 h

Cars pass when the distances are equal, $d_A = d_B$.
d_A = 48.0 km + (36.0 km/h)t and d_B = 0 + (48.0 km/h)(t – 0.50 h), so
48.0 km + (36.0 km/h)t = (48.0 km/h)(t – 0.50 h)
48.0 km + (36.0 km/h)t = (48.0 km/h)t – 24 km
72 km = (12.0 km/h)t
t = 6.0 h

b. At what position will the passing occur?

d_A = 48.0 km + (36.0 km/h)(6.0 h) = 2.6 × 10² km

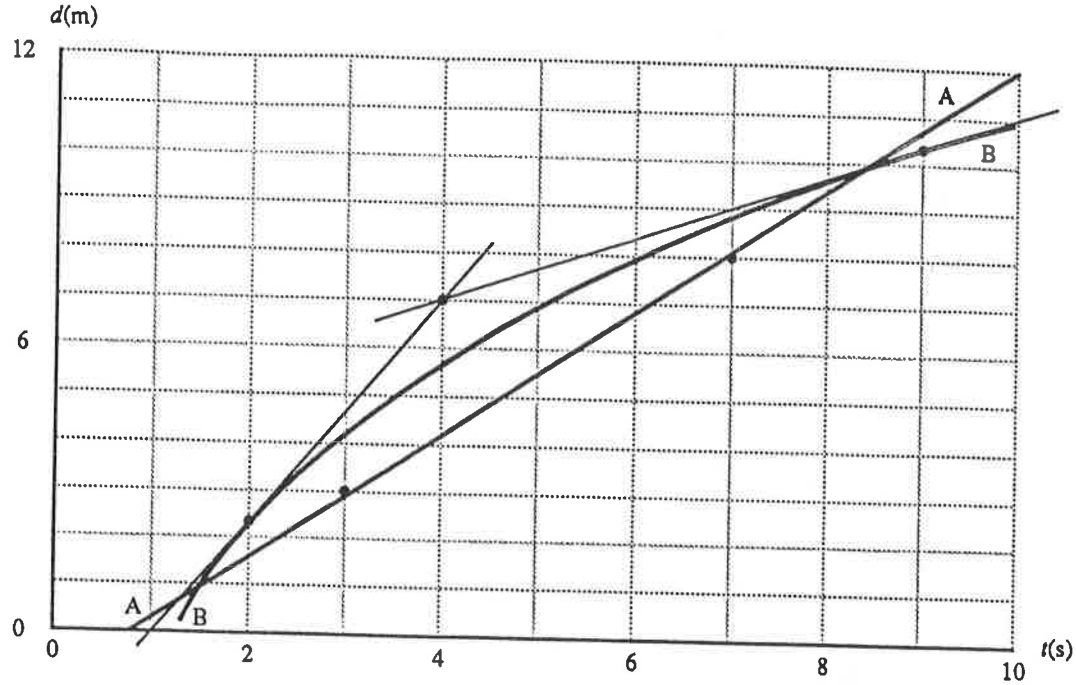
c. When the cars pass, how long will it have been since car A was at the reference point?

$$d = vt, \text{ so } t \frac{d}{v} = \frac{-48.0 \text{ km}}{36.0 \text{ km/h}} = -1.33 \text{ h}$$

Car A started 1.33 h before the clock started.

t = 6.0 h + 1.3 h = 7.3 h

21.



Refer to Figure 3–22 to find the instantaneous speed for

a. car B at 2.0 s

$$\text{slope} = \frac{\Delta d}{\Delta t} = \frac{7\text{ m} - 0\text{ m}}{4\text{ s} - 1\text{ s}} = 2.3\text{ m/s}$$

b. car B at 9.0 s

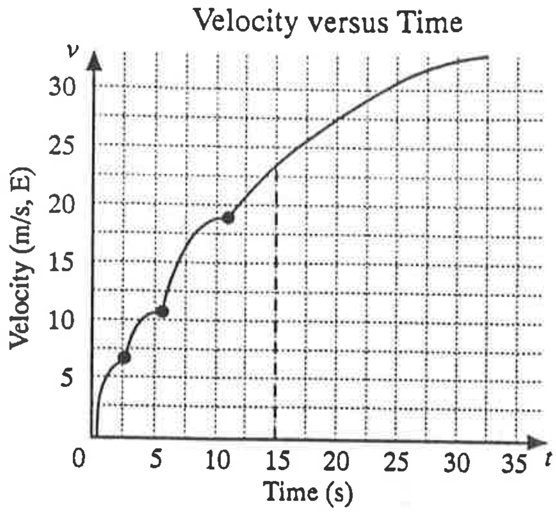
$$\text{slope} = \frac{\Delta d}{\Delta t} = \frac{11\text{ m} - 7\text{ m}}{10\text{ s} - 4\text{ s}} = 0.67\text{ m/s}$$

c. car A at 2.0 s

$$\text{slope} = \frac{\Delta d}{\Delta t} = \frac{8\text{ m} - 3\text{m}}{7\text{ s} - 3\text{ s}} = 1.25\text{ m/s}$$

Student answers will vary.

22. Find the instantaneous speed of the car at 15 s from Figure 3–19.



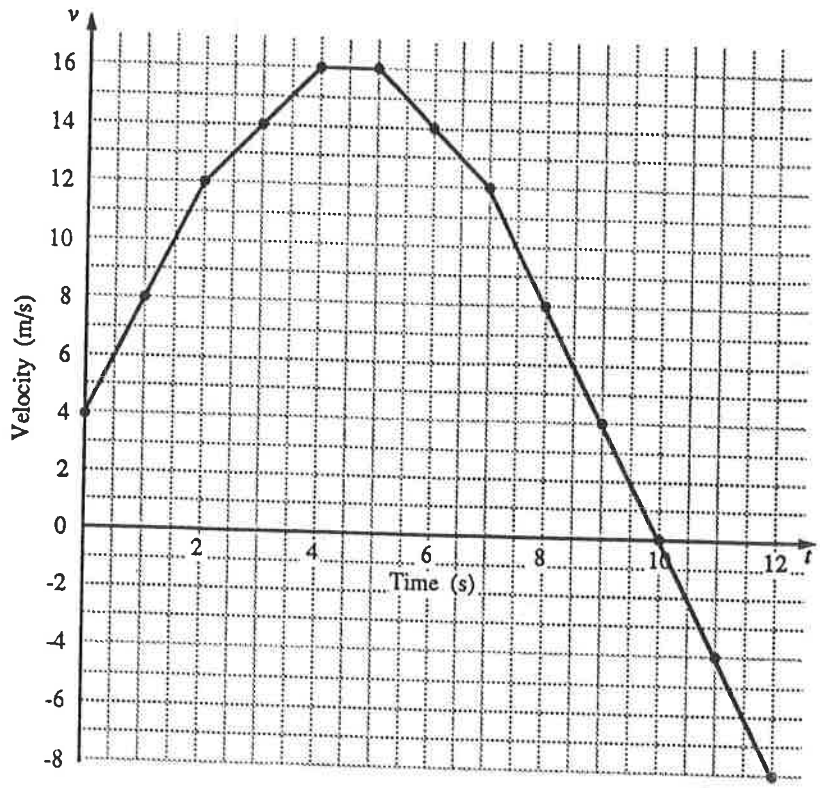
Student answer will vary.

Approximately 23 m/s

3

23. Plot a velocity–time graph using the information in Table 3–4.

Time (s)	Velocity (m/s)	Time (s)	Velocity (m/s)
0.0	4.0	7.0	12.0
1.0	8.0	8.0	8.0
2.0	12.0	9.0	4.0
3.0	14.0	10.0	0.0
4.0	16.0	11.0	–4.0
5.0	16.0	12.0	–8.0
6.0	14.0		



24. Refer to Figure 3–25 to find the distance the moving object travels

a. between t = 0 s and t = 5 s.

Area I $= \frac{1}{2}bh = \frac{1}{2}(5\text{s})(30 \text{ m/s}) = 75 \text{ m}$

b. between t = 5 s and t = 10 s.

Area II $= bh = (10 \text{ s} - 5 \text{ s})(30 \text{ m/s}) = 150 \text{ m}$

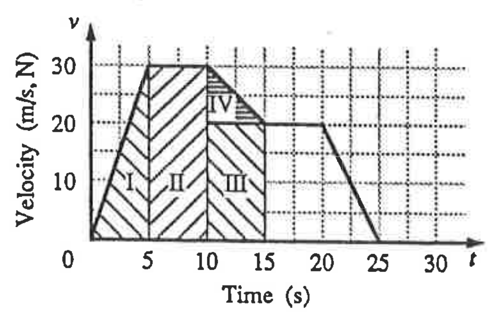
c. between t = 10 s and t = 15 s.

Area III + Area IV $= bh + \frac{1}{2}bh = (15 \text{ s} - 10 \text{ s})(20 \text{ m/s}) + \frac{1}{2}(15 \text{ s} - 10 \text{ s})(10 \text{ m/s})$

$= 100 \text{ m} + 25 \text{ m} = 125 \text{ m}$

d. between t = 0 s and t = 25 s.

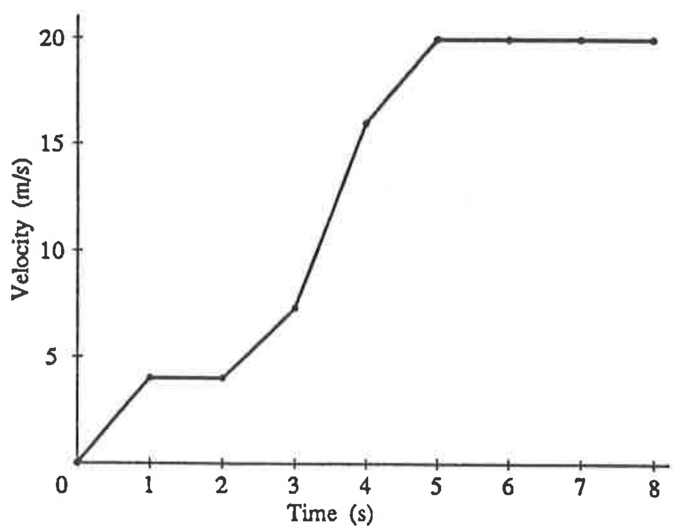
75 m + 150 m + 125 m + 100 m + 50 m = 500 m



25. The velocity of an automobile changes over an 8.0–s time period as shown in Table 3–5.

Time (s)	Velocity (m/s)	Time (s)	Velocity (m/s)
0.0	0.0	5.0	20.0
1.0	4.0	6.0	20.0
2.0	4.0	7.0	20.0
3.0	8.0	8.0	20.0
4.0	16.0		

a. Plot the velocity–time graph of the motion.



b. Determine the distance the car travels during the first 2.0 s.

$\Delta d = \frac{1}{2}(1.0\text{ s})(4.0\text{ m/s}) + (1.0\text{ s})(4.0\text{ m/s}) = 6.0\text{ m}$

c. What distance does the car travel during the first 4.0 s?

$\Delta d = 6.0\text{ m} + \frac{1}{2}(1.0\text{ s})(8.0\text{ m/s} - 4.0\text{ m/s}) + (1.0\text{ s})(4.0\text{ m/s}) + \frac{1}{2}(1.0\text{ s})(16.0\text{ m/s} - 8.0\text{ m/s})$
$+ (1.0\text{ s})(8.0\text{ m/s}) = 24\text{ m}$

d. What distance does the car travel during the entire 8.0 s?

$\Delta d = 24\text{ m} + (1.0\text{ s})(16.0\text{ m/s}) + \frac{1}{2}(1.0\text{ s})(20.0\text{ m/s} - 16.0\text{ m/s}) + (3.0\text{ s})(20.0\text{ m/s})$
$= 102\text{ m}$